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Recent results on charmless hadronic B decays at Belle

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Abstract

Two-body charmless hadronic decays of B mesons are important for determining Standard Model parameters and for detecting the presence of new physics. We present recent results from the Belle experiment on the charmless hadronic decays $B \rightarrow \eta\pi^0$ and $B \rightarrow \pi^0\pi^0$.

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1 Introduction

Two-body charmless hadronic decays of B mesons are important for determining Standard Model parameters and for detecting the presence of new physics. We present recent results from the Belle experiment on the charmless hadronic decays $B \rightarrow \eta\pi^0$ and $B \rightarrow \pi^0\pi^0$.

2 Evidence for the decay $B \rightarrow \eta\pi^0$

The decay $B \rightarrow \eta\pi^0$ proceeds mainly via a $b \rightarrow u$ Cabibbo- and color-suppressed “tree” diagram, and via a $b \rightarrow d$ “penguin” diagram, as shown in Fig. 1. The branching fraction can be used to constrain isospin-breaking effects on the value of $\sin 2\phi_2$ ($\sin 2\alpha$) measured in $B \rightarrow \pi\pi$ decays [1, 2]. It can also be used to constrain CP -violating parameters ($C_{\eta'K}$ and $S_{\eta'K}$) governing the time dependence of $B^0 \rightarrow \eta'K^0$ decays [3]. The branching fraction is estimated using QCD factorization [4], soft collinear effective field theory [5], and flavor $SU(3)$ symmetry [6] and is found to be in the range $(2 - 12) \times 10^{-7}$.

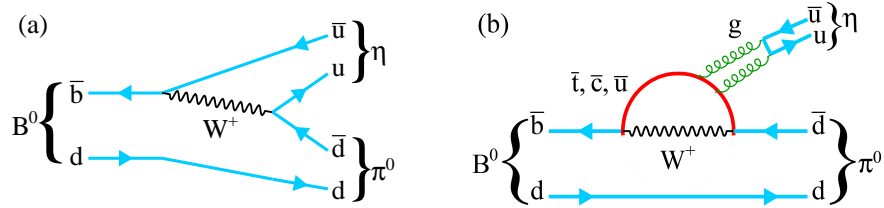


Figure 1: (a) Tree and (b) penguin diagram contributions to $B \rightarrow \eta\pi^0$.

Several experiments [7, 8, 9, 10, 11], including Belle, have searched for this decay mode. The current most stringent limit on the branching fraction is $\mathcal{B}(B^0 \rightarrow \eta\pi^0) < 1.5 \times 10^{-6}$ at 90% confidence level (C.L.) [11]. The analysis presented here uses the full data set of the Belle experiment running on the $\Upsilon(4S)$ resonance at the KEKB asymmetric-energy e^+e^- collider. This data set corresponds to 753×10^6 $B\bar{B}$ pairs, which is a factor of 5 larger than that used previously. Improved tracking, photon reconstruction, and continuum suppression algorithms are also used in this analysis.

We find the evidence of the decay $B \rightarrow \eta\pi^0$ [12], where the candidate η mesons are reconstructed via $\eta \rightarrow \gamma\gamma$ ($\eta_{\gamma\gamma}$) and $\eta \rightarrow \pi^+\pi^-\pi^0$ ($\eta_{3\pi}$) decays and π^0 via $\pi^0 \rightarrow \gamma\gamma$. Results of the fit to the variables, beam-energy-constrained mass $M_{bc} = \sqrt{E_{\text{beam}}^2 - |\vec{p}_B|^2 c^2 / c^2}$, energy difference $\Delta E = E_B - E_{\text{beam}}$ and continuum suppression variable $C'_{NB} = \ln\left(\frac{C_{NB} - C_{NB}^{\min}}{C_{NB}^{\max} - C_{NB}}\right)$, are given in Table. 1. The combined branching fraction

Table 1: Fitted signal yield Y_{sig} , reconstruction efficiency ϵ , η decay branching fraction \mathcal{B}_η , signal significance, and B^0 branching fraction \mathcal{B} for the decay $B^0 \rightarrow \eta\pi^0$. The errors listed are statistical only. The significance includes both statistical and systematic uncertainties.

Mode	Y_{sig}	$\epsilon(\%)$	$\mathcal{B}_\eta(\%)$	Significance	$\mathcal{B}(10^{-7})$
$B^0 \rightarrow \eta_{\gamma\gamma}\pi^0$	$30.6^{+12.2}_{-10.8}$	18.4	39.41	3.1	$5.6^{+2.2}_{-2.0}$
$B^0 \rightarrow \eta_{3\pi}\pi^0$	$0.5^{+6.6}_{-5.4}$	14.2	22.92	0.1	$0.2^{+2.8}_{-2.3}$
Combined				3.0	$4.1^{+1.7}_{-1.5}$

is determined by simultaneously fitting both $B^0 \rightarrow \eta_{\gamma\gamma}\pi^0$ and $B^0 \rightarrow \eta_{3\pi}\pi^0$ samples for a common $\mathcal{B}(B^0 \rightarrow \eta\pi^0)$. Signal enhanced projections of the simultaneous fit are shown in Fig. 2. The branching fraction for $B \rightarrow \eta\pi^0$ decays is measured to be

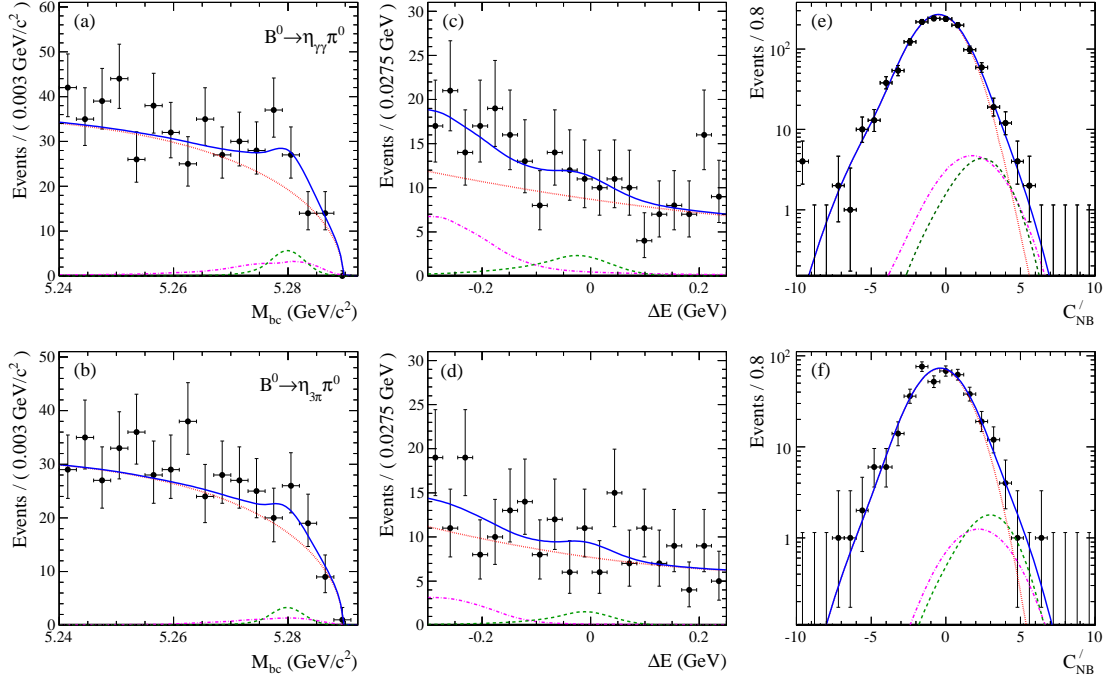


Figure 2: Signal enhanced projections of the simultaneous fit for the decay $B^0 \rightarrow \eta\pi^0$: (a), (b) M_{bc} ; (c), (d) ΔE ; (e), (f) C'_{NB} . The top (bottom) row corresponds to $\eta \rightarrow \gamma\gamma$ ($\eta \rightarrow \pi^+\pi^-\pi^0$) decays. Points with error bars are data; the (green) dashed, (red) dotted and (magenta) dot-dashed curves represent the signal, continuum and charmless rare backgrounds, respectively, and the (blue) solid curves represent the total PDF.

$$\mathcal{B}(B^0 \rightarrow \eta\pi^0) = \left(4.1^{+1.7+0.5}_{-1.5-0.7}\right) \times 10^{-7},$$

where the first uncertainty is statistical and the second is systematic. This corresponds to a 90% C.L. upper limit of $\mathcal{B}(B^0 \rightarrow \eta\pi^0) < 6.5 \times 10^{-7}$. The significance of this result is 3.0 standard deviations. The measured branching fraction is in good agreement with theoretical expectations [4, 5, 6]. Inserting our measured value into Eq. (19) of Ref. [1] gives the result that the isospin-breaking correction to the weak phase ϕ_2 measured in $B \rightarrow \pi\pi$ decays due to π^0 - η - η' mixing is less than 0.97° at 90% C.L.

3 The decay $B^0 \rightarrow \pi^0\pi^0$ (preliminary results)

This decay is an important input for the isospin analysis in the $B \rightarrow \pi\pi$ system. A fit to the variables ΔE , M_{bc} and a fisher discriminant T_C is performed. We measure a preliminary branching fraction of $\mathcal{B}(B^0 \rightarrow \pi^0\pi^0) = (0.9 \pm 0.12(\text{stat.}) \pm 0.10(\text{sys.})) \times 10^{-6}$, with a significance of 6.7 standard deviations and the direct CP asymmetry of $A_{CP} = -0.054 \pm 0.086$. Signal enhanced projections are shown in Fig. 3. With this result, the constraint to the ϕ_2 using the isospin relation in the $B \rightarrow \pi\pi$ system will be re-evaluated.

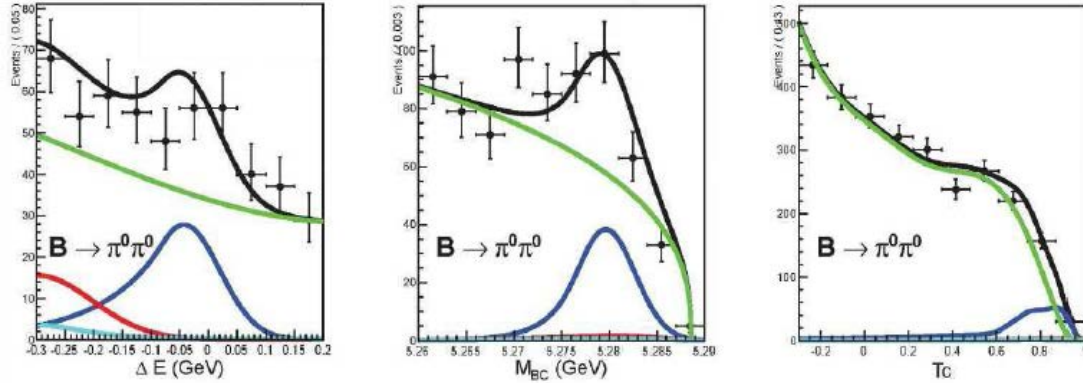


Figure 3: Signal enhanced projections of the fit for the decay $B^0 \rightarrow \pi^0\pi^0$: (left) ΔE , (middle) M_{bc} and (right) T_C . Contributions from signal, continuum, $\rho\pi^+$ and other B decays are shown by blue, green, red and cyan curves respectively.

4 Summary

Using the full set of Belle data, recent and preliminary measurements of charmless hadronic B decays are presented. Our measurement of $B^0 \rightarrow \eta\pi^0$ branching fraction constitutes the first evidence of the decay.

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